SUPPLIER SELECTION CRITERIA IN DIFFERENT PROJECT ENVIRONMENTS: AN EMPIRICAL STUDY

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ABSTRACT
Research in identifying the relative importance of criteria used to select a preferred supplier has, for the most part, relied on subjective lists of criteria being presented to respondents. This paper is a summary of the research conducted by the authors to quantify the importance of nine common criteria used in an actual evaluation and selection of a contractor/supplier. Unique choice sets were constructed, each comprising 3 tender evaluation outcomes (alternatives) described in terms of all criteria, but with varying levels. Respondents simultaneously evaluated all three alternatives within each choice set and selected the most preferred. Utility estimates for each criterion level were determined as was the overall contribution made by the individual criterion. Results indicate past project performance, technical expertise and cost are the most important criteria in an actual choice of contractor with organisational experience, workload, and reputation being the least important.

INTRODUCTION
Tender evaluation and contractor selection continues to be an area of significant importance and interest to organisations responsible for delivering project outcomes. Occurring early in the project lifecycle, it is perhaps one of the most critical undertakings performed by clients, the effectiveness of which is directly related to project success and the achievement of specified objectives (Alsugair, 1999; Holt, et al. 1994; Lopes and Flavell, 1998). The environment for making judgments about suppliers and their ability to deliver is complex, comprising high levels of ambiguity and uncertainty, competing stakeholder values and complicated relationships as a result of multiple conflicting objectives (Hatush and Skitmore, 1997a; Keeney and Raiffa, 1976; Ng and Skitmore, 2001; Watt, et al. 2009). Further complications arise in identifying suitable and relevant criteria and assigning appropriate weights, all of which are likely to vary as a function of many factors, least of which are the organisational objectives and experience of the evaluator.

Given the complexities and underlying issues surrounding contractor selection, and the variety of criteria available, the question is how to choose suppliers and what is the relationship between the criteria used in an evaluation? Which criteria influence choice? Is price a more important criterion than experience, capability, expertise, or performance? Does the relative importance vary as a function of industry, position, experience or project complexity? These questions form the basis of our continuing research to investigate which factors influence the actual choice of a contractor for major projects and the relative importance of the criteria used. Despite its significance, this aspect of contractor selection remains largely unexplored, as evidenced by the very few studies reported.

The importance of the criteria used to evaluate and select contractors or suppliers has been examined under various industrial purchasing situations. These include the supply of professional management services and procurement of capital equipment and systems, through to the delivery of large scale projects (Alsugair, 1999; Cardozo and Cagley, 1971; Dempsey, 1978; Dickson, 1966; Hakansson and Wootz, 1975; Hatush and Skitmore, 1997a; Hensher et al. 2000; Holt, et al. 1994). Criteria included those in which evaluators could gauge contractors and their likely performance across key project

dimensions; relevant experience, track record, quality, expertise, capability, cost, safety record, and capacity to name a few. In terms of the their importance in evaluating and selecting contractors, these studies showed that no individual criteria or group of criteria are consistently reported as being more important than others.

Despite the comprehensive nature of these studies, none except that provided by Hensher et al. (2000) studied how clients actually choose contractors. All relied on attitudinal surveys in which respondents were asked to directly and independently rate the "perceived importance" of specified criteria. Ranking studies, whilst useful in identifying relevant criteria do not represent an actual tender situation. The iterative nature and mechanistic process in which respondents consider and rank individual criteria within a defined group provides little insight into the decision making behaviour. An actual choice of contractor requires evaluators to consider each contractor simultaneously as a function of all specified criteria and their assigned weightings.

Our research uses a Discrete Choice Experiment (DCE) in which respondents simultaneously evaluate the characteristics of contractors as a function of the level or value assigned to individual criterion. The main advantage of the approach is that respondents do not rate the importance of specified criteria directly. Rather, each alternative within a set is considered wholistically. The structure of the experiment is such that no individual tenderer (alternative) dominated across all criteria, necessitating respondents to make conscious trade-offs.

Next sections of the paper outline the research design methodology followed by an analysis and discussion of the relative importance of the criteria used in evaluating contractors. The final section summarises and concludes the article, along with suggestions for future research.

RESEARCH DESIGN METHODOLOGY

An empirical study to investigate the contractor evaluation and selection process for the delivery of projects and the importance was used for contractor selection which is an industry specific task. The sample group included Engineering Project Contract Management (EPCM) companies known to have experience in delivering large scale projects or in the provision of management services. The population included several international organisations and Australian companies within the mining and exploration, construction, defence and aerospace, manufacturing and processing and telecommunications sectors. Executives, programme and project managers and engineering managers were identified and contacted by telephone or e-mail seeking their participation in the survey.

In all 288 prospective respondents were identified, of which 255 agreed to participate. A questionnaire and covering letter setting out the research objectives and a brief description was distributed between September 2007 and April 2008. Of the 255 respondents who agreed to participate, and after some follow up, 222 completed surveys were returned, giving a response rate around 87%. Respondents, when initially contacted, expressed a genuine interest in the research topic, which is believed to be the main factor contributing to such an unusually high response rate.

The survey instrument comprised of two main sections. The first asked respondents to describe their organisation and the industry sector within which they work, along with their experience, role, and characteristics of projects they had previously worked on over the past ten years. In addition, respondents were also asked to describe a previous project in terms of budget, schedule, industry and complexity. This served as a reference project for the Discrete Choice Experiment (second) component of the study. It ensured the experiment was context-dependent relative to each respondent and that results could be generalised.

The Discrete Choice Experiment contained 1 block of 16 scenarios, or choice sets, each comprising 3 alternatives that represented a typical tender evaluation outcome. Each alternative was defined in terms of eight criteria (attributes) identified from research undertaken by Watt et al. (2009), plus tendered price, giving a total of nine attributes. Prior to implementing the survey, a pilot study was conducted to ensure clarity and understanding of the questionnaire, comprehension of the Discrete Choice task and to suggest improvements where necessary. Fifteen senior managers from the construction, defence and mining industries were interviewed all of who suggested minor formatting changes to enhance clarity. Two (2) respondents suggested including definitions for each of the nine (9) criteria to remove any ambiguity. Average time to complete the survey was approximately 30 minutes with respondents indicating no difficulty in performing the task.

Analysis and modelling utilised the Multinomial Logit based on the technique of maximum likelihood estimation as described in Louviere and Timmermans (1990) and McFadden (1986). Estimates were initially calculated for all levels of all criteria relative to their lowest (base) level and the model log-likelihood recorded. The process was repeated a further nine times after removing, in turn, one criterion and all its associated levels. This provided a common metric where the difference in log-likelihoods between the full model (all criteria included) and those absent a given criteria, quantified the relative effect of each attribute on the dependent variable, choice.

Relevant criteria were identified from previous research undertaken by Watt et al. (2009). The resulting design structure is represented in Table 1.

Table 1
Design Structure - Criteria (Attributes) and Defined Levels

Criteria/Attribute	Level 1	Level 2	Level 3	Level 4
Organisational Experience	< 2 years	2 to < 5 years	5 to < 10 years	> 10 years
Project Management Expertise	Low	Satisfactory	Very Good	Excellent
Tendered Price	10% Below Tender Average	5% Below Tender Average	5% Above Tender Average	10% Above Tender Average
Technical Expertise	Poor	Marginal	Above Average	High
Past Project Performance	Unsatisfactory	Average	Good	Very Good
Company Standing (Reputation)	Not Known	Neutral	Reputable	N/A – Not Used
Method/Solution	Mostly Feasible	Established, not Proven	Established and Proven	N/A – Not Used
Client-Supplier Relations	Average	Good	Excellent	N/A – Not Used
Workload/Capacity	Few Projects, Excess Capacity	Several Projects, Adequate Capacity	Many Projects, Limited Capacity	N/A – Not Used

A full factorial design for the structure provided in Table 1 represents 82,944 ($4^5 \times 3^4$) possible combinations and requires many thousands of choice sets to capture all parameter estimates and interaction effects.

RESULTS AND DISCUSSION

Respondent data was collected for both the general and discrete choice experiment components of the study. The first elicited data that described the participants, industry, experience, and role within the organisation, along with information on projects they had previously managed. In addition, respondents provided details of a project they had previously managed or conducted a tender evaluation on. Data from the discrete choice experiment was also captured and recorded. This required respondents to evaluate 16 independent tender evaluation outcomes comprising three alternatives, and select the most preferred.

General results

Two hundred and twenty two completed questionnaires were received from two hundred and fifty five individuals who agreed to participate in the study. Most respondents represented organisations that either provided project based services and support to clients, or an organisation directly contracted for the delivery of a major project. The client perspective, comprised respondents in which they, or their organisation, were recipients of a service or outcomes of a project. Representation between the provider and client perspective constituted approximately 79% and 21% of participants, respectively.

The main roles and functions reported were executives, project directors, programme and project managers, collectively representing approximately 87% of respondents. The largest category comprised Program and Project Managers representing 45% of respondents, followed by Executives, Directors, and General Managers with 25%, then Project Directors with 17%. The remaining categories, Engineering Operations Management, Engineering and Other represented 5%, 3% and 5% respectively. Example roles and functions within the category labelled "Other" included Business Development Manager, Procurement Manager, Sales Manager and Field Services Manager.

Five categories relating to the respondents years of experience were used in the study; 0 to 2.99, 3 to 4.99, 5 to 9.99, 10 to 19.99 and 20 years or greater. Respondents with less than 10 years experience constituted approximately 22%. The remaining 78% with 10 years experience or greater included the two sub-categories, 10 to 19.99 years and 20 years or greater. Respectively each accounted for approximately 43% and 34% of respondents.

Construction, Defence and Aerospace, Infrastructure and Energy, Manufacturing and Processing, and Mining and Exploration were represented equally with approximately 17.56%, or 39 of the 222 respondents, for a collective 87.8%. The Telecommunications and Information Technology category was the next largest represented with approximately 5%, or 11 respondents. The two categories of Biotechnology and Pharmaceutical, and "Other" were the least represented, with each comprising ~ 3%, or 7 of the 222 respondents. Industries in this latter category included, Banking and Finance, Medical and Environmental. Two respondents (1%) provided no reference industry, and recorded as Not Provided (NP).

Discrete Choice Analysis

Each the 222 respondent evaluated 16 individual Choice Sets comprising 3 alternatives, for a total of 10656 observations. A Multinomial Logit model (MNL) was specified and Maximum Likelihood Estimation (MLE) used to determine the utility estimates for all levels of criteria (attribute) under consideration. The results show a clear preference ordering, in that the utility estimates increase as the level of a criterion improves. For example, consider the criterion of Past Performance and the four discrete levels assigned for this study. Tenderers represented by the base (reference) level, "Unsatisfactory" are the least preferred, as one would expect. However, as the level of Past Performance or delivery record increases, so to do the utility estimates. Tenderers with "Very Good" past performance are the most preferred. Similarly, for Tendered Price, the base level

representing "10% Below Tender Average" is the most preferred, with the least preferred being "10% Above Tender Average." For Technical Expertise, utility increases with increases in levels of expertise until utility is maximised at level 3, "Above Average". At this point, increasing the applied level of technical expertise provides a marginal decrease in utility, inferring that the primary consideration is for the contracting organisation to have at least "Above Average" technical expertise.

The difference in utility provided with increasing levels applicable to Method/Solution and Workload/capacity is significant. For Method/Solution, the preference for tenderers who have established approaches and/or systems (Existing and Proven) is higher than those in which equivalent approaches and/or systems exist, but are yet to be proven. With regard to "Workload/Capacity", the negative utility indicates less desirability for contractors with many projects and little available capacity over tenderers who have some projects under contract, but also have additional capacity. For Organisational Experience the gain in utility between the two highest levels is marginal, suggesting that those organisations with 5 years experience or more is all that is relevant in an evaluation. Similarly, for Project Management Expertise, the additional utility afforded by moving from "Very Good" to "Excellent" is also marginal, but doubles in going from "Satisfactory" to "Very Good", suggesting that the desirability of tenderers with anything other than "Satisfactory", is the primary consideration.

In terms of Client Relations and Company Standing (Reputation), again the result shows an increase in utility as the level of the attribute increases. In both cases, the utility estimate doubles, or almost so, as the level increases from the base (reference) level through the mid, to the highest level. This suggests higher importance is placed on reputable tenderers with an excellent client relations record, therefore reflecting a higher probability of choosing a tenderer to which these higher levels of the criterion are applied.

The results show greater importance is placed on past performance, or track record, technical expertise, cost and management, indicating that respondents are likely to assign more weight to these during an actual evaluation. Specifically, Past Project Performance and Technical Expertise are the two most important criteria followed by Tendered Price and Project Management Expertise. In addition, Project Performance and Technical Expertise are almost of equal importance, but twice that of Tendered Price and three times more important than Project Management Expertise. The collective importance of these four criteria exceeds 85%, whilst the remaining five (organisational) contribute less than 15%.

CONCLUSION

Tender evaluation and contractor selection for the delivery of major projects and services is acknowledged as a complex undertaking that embodies many uncertainties. The criteria used for making judgments about potential suppliers and their ability to deliver are varied and many, and often traded-off on the basis of multiple conflicting objectives. The research reported here investigated the contractor selection process to establish the relative importance of common criteria used in the actual choice of contractor.

The study used an experimental design approach as an alternative to attitudinal studies in which respondents rate, directly, the perceived importance of each in the context of contractor selection. The technique generated groups (choice sets) of three alternatives each comprising the same nine criteria, but with different levels. The design structure ensured no individual contractor (alternative) dominated across all criteria. Respondents considered, simultaneously, each contractor from each group and selected the most preferred.

Parameter estimates for all levels of the nine criteria were established using the Multinomial Logit Model. The model log-likelihood was also recorded with all criteria and levels included, and again after each criterion and its associated levels were removed. This provided a basis in which the relative importance of the criteria could be established. Results were statistically significant, indicating past performance, technical expertise, and cost are amongst the most important in the actual choice of contractor and organisational criteria were considerably less important. In particular, Past Project Performance and Technical Expertise were of almost equal importance, but twice that of Tendered Cost. These coupled with Project Management Expertise and Tendered Price contributed to a combined importance in excess of 85%, whereas organisational criteria contributed less than 15%.

The results provide an important contribution to the topic of contractor evaluation. In particular, our research emphasises the importance of common criteria used in an actual choice of contractor, and draws on novel techniques used by other disciplines. The specific importance values, relative to each criterion, can be used to guide the development of weighting schemes in evaluation systems. Accordingly, better alignment between the expectations of client organisations and tenderers, particularly with respect to experience, capability and performance are expected to be established.

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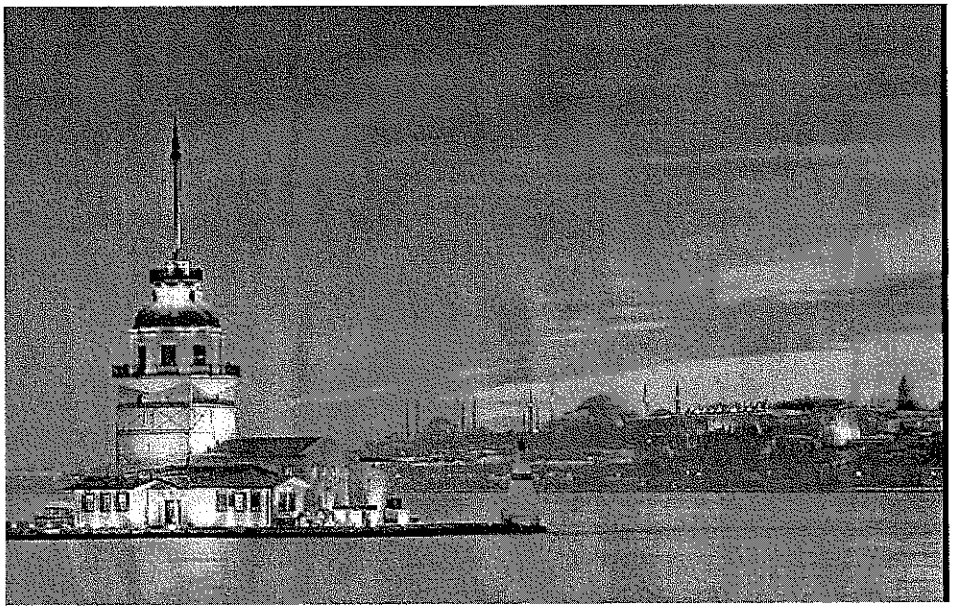

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